

Temporary Exchange-Rate-Based Stabilization Plans:
An analysis of the effects on output, consumption, and
welfare when money serves a productive role

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Abstract

This paper investigates the effects on production, consumption, and welfare that result from a temporary exchange-rate-based (ERB) stabilization plan. The analysis is based on an optimizing model of a small open economy where real money is assumed to be a factor that is used in the production of goods. The assumption of money serving a productive role makes the model capable of generating a boom-bust cycle in output, as is often experienced during ERB stabilization plans. It is shown that a temporary decrease in the rate of exchange rate devaluation shifts the flat consumption profile upwards, thereby causing a “permanent” effect of the temporary stabilization plan, if at least one of the following two conditions is satisfied: The stabilization plan is expected not to be too short and/or some of the increase in output in the initial phase of the stabilization plan is saved for later periods after the plan has broken down. If at least one of these two conditions is fulfilled, the utility of the representative consumer is increased when the rate of devaluation is reduced. On the other hand, if the plan is not sufficiently credible at the outset, or there is not enough intertemporal transference of output, the stabilization plan is likely to be harmful to economic welfare.

Keywords: Exchange-rate-based stabilization plans, temporariness, non-neutrality of money, boom-bust output cycles, speculative currency attacks

JEL-classification: E51, E52, F31, F41

“We also believe that the evidence supports the idea that the nominal anchor matters and that, other things equal, exchange-rate-based stabilizations are more likely to be expansionary..... This is why exchange-rate-based stabilizations are so attractive as a means of reducing inflation from very high levels - even though the issue of how to exit from a peg before the advent of a potential crisis remains unresolved” – Fisher, Sahay, and Végh (2002).

1 Introduction

When the exchange-rate-based (ERB) stabilization plans for the Latin America’s Southern Cone were launched in the late 1970s and, for that matter, the plans of countries like Argentina, Brazil, Israel, and Mexico in the 1980s and 1990s, the hope was that the plans would help bring down the high rates of inflation that plagued these countries. More often than not, though, the plans ended in currency crises – and the reduction in the rates of devaluation and inflation remained temporary only.

In their survey, Calvo & Végh (1999) report that the literature has come a long way in developing models that can explain many of the empirical regularities associated with exchange-rate-based stabilization plans. These regularities include, in addition to the temporary reduction in inflation and the final currency crisis, initial booms in production and consumption that are often followed by recessions, real exchange rate appreciations, and current account deficits.¹ As also noted in Calvo & Végh (1999), though, one question that the models still leave open is the following: when, if ever, are temporary ERB stabilization plans welfare-improving? This is an intriguing question. If a temporary stabilization plan is not welfare-improving, it is for instance unclear why it would ever be a good idea to introduce it in the first place. It is also unclear why some countries continue to introduce exchange-rate-based stabilization plans that remain temporary only, such as Argentina, Brazil, Mexico, and Uruguay; see Table 1 in Calvo & Végh (1999).

The currency crises of the 1990s (e.g. the ERM, Tequila, and the Asian currency crises) and particularly the problems in Argentina in 2001/2002 have revived interest in better understanding the appropriateness of different kinds of exchange-rate arrangements. This paper aims at contributing to this understanding by analyzing some of the merits as well as some of

¹Végh (1992), Calvo & Végh (1999), and Fisher *et al.* (2002) provide detailed evidence on the empirical macroeconomic effects of ERB stabilization plans. Henry (2002) studies the effects for the stock markets.

the deficiencies associated with the implementation of ERB stabilization plans. In particular, the paper will reexamine what happens to output, consumption and, in the end, welfare when the rate of devaluation is temporarily reduced.

The analysis provided in the paper will take its departure from a simple optimizing dynamic model inspired by the literature on speculative currency attacks and exchange-rate-based stabilization plans but redesigned so as to capture some of the more important empirical characteristics of ERB stabilization plans. Within this framework, the paper will analyze the conditions under which a *temporary* decrease in the rate of devaluation will lead to a *permanent* positive effect on the level of consumption. Basically, any such positive effect on the level of consumption influences the utility of the representative consumer in a positive manner and exchange-rate-based stabilization plans, even if they are known to be temporary only, can potentially increase welfare. On the other hand, by studying the conditions needed to make consumption change in a positive direction, it can also be analyzed how temporary ERB plans can lead to negative welfare effects if these conditions are not met.

The main reason why the model here predicts that consumption changes as a result of the stabilization plan is that it is assumed that money facilitates firms' production and therefore influences the supply of goods, and in the end income, in the economy. To be more specific, firms hold relatively more money during periods when the stabilization plans are effective and inflation rates are low. It is assumed that these larger holdings of money affect production and income in a positive direction because money holdings enter the production function of firms. Essentially, the paper thus incorporates a productive role of money into the models of exchange-rate-based stabilization plans that end with currency crises, and finds that the unanticipated reduction in inflation that is associated with the implementation of the stabilization plan leads to higher production temporarily, i.e. a boom-bust cycle in real production. This boom-bust cycle in output is important to capture because "for ERBS (exchange-rate-based stabilizations), GDP growth rises very sharply upon stabilization – from an already positive value in the year before stabilization – and then stays high until $T + 2$ (two year after stabilization) only to fall sharply in year $T + 3$ (three years after stabilization)", Fisher *et al.* (2002), pp. 868.

The most important result of the paper will be that the increase in income spurs increased consumption if at least one of the following two conditions is satisfied: the stabilization plan is expected not to be too short and/or the interest earnings from the foreign exchange reserves are not too large relative to other government revenues such as, for instance, income taxes. The

paper argues that in particular the latter of these two conditions provides an interesting new perspective to the literature on temporary ERB stabilization plans, as it points in one direction whereby such plans can potentially be made welfare-improving. If the temporary ERB plan initially leads to higher production, but also a loss of income after the plan has broken down, there will be situations where it can be utility-enhancing to tax away some of the initial increase in income and save the revenues for use in periods after the plan has broken down and output is low. The paper will show how to set tax rates in such situations. It is found that these tax rates are related to the relative sizes of the revenues generated from general income taxes and the revenues generated from interest earnings and capital gains from the foreign exchange reserves. In this sense, the paper makes clear that credible ERB plans, possibly combined with a smoothing out of the increase in production, can be utility-enhancing; however, as the paper also makes clear, it cannot be taken for granted that implementations of ERB stabilization plans will be beneficial to the economy. The latter point is especially true if (i) the ERB plan is not credible when implemented (is not believed to last sufficiently long) and/or (ii) the government loses very large foreign exchange reserves in attempts to defend less credible ERB stabilization plans.²

To briefly review what gives rise to these results, it is recognized that the agents in the economy know that the stabilization plan is temporary only, and they also know the exact duration of the ERB plan with its low rate of devaluation. This is so because the agents understand that the seigniorage revenues to the government will decrease when the ERB plan is introduced, as in the original Krugman (1979)/Flood & Garber (1984) model.³ Given a certain level of government expenditures, a reduction in government revenues is assumed to imply that the government will be forced to increase the rate of devaluation again at a later stage of the stabilization plan. When the agents foresee that an increase in the rate of devaluation is inevitable, they would like to control the date in time where the rate of devaluation is increased, and this they can do by means of a speculative attack on the exchange rate as in the original

²It is noted in the paper that the theoretical results on the usefulness of intertemporal transference of output are not purely theoretical curiosities as they have an empirical variant in the so-called “buffer funds” launched in Finland before Finland joined the third phase of EMU in 1999. The idea with these funds, as will be discussed later, was that financial reserves could be built up during good times such that the reserves could be used to finance different kinds of social contributions during bad times. In addition to Finland, Sweden too has recently considered use of buffer-funds; see the Ministry of Finance, Sweden (2002).

³The paper will also discuss the conditions under which the introduction of an ERB stabilization plan leads to a reduction in seigniorage revenues.

Krugman (1979) model.

Why, then, do the temporary effects on production turn into permanent effects on consumption and utility? The permanent effects are obtained as a consequence of using the small-open-economy specification of the model. As is the usual assumption in models of small open economies (see for instance Blanchard & Fisher, 1989, chapter 2), the constant international real interest rate equals the representative individual's rate of time preferences in order to secure a well-determined steady-state solution for the otherwise dynamic variables. In the absence of unanticipated shocks, this assumption implies that consumption is constant. Furthermore, in the small open economy, anticipated temporary changes in income and production will be spread out over the life horizon of the agents as these will perfectly smooth out changes in consumption and thereby keep consumption constant. In times when income is high, the agents will save and thereby increase their holdings of international assets; when income is low, they will rely on previously accumulated international assets. The path of international assets in the hands of consumers thus plays an important role when adjusting consumption to transitory disturbances to real income. Therefore, the temporary increase in production, resulting from the temporary reduction in the rate of devaluation, makes consumers in the small open economy permanently change consumption, primarily through adjustments of their portfolio holdings of the international assets.

In addition to the above-mentioned findings, the paper provides another potentially interesting result. In the standard Krugman (1979)/Flood & Garber (1984) model, it is the elasticity of the consumers' money-demand function with respect to the interest rate that sparks the speculative attack. However, if this elasticity equals zero, no speculative attack will occur; this is a situation labelled "the natural collapse" by Grilli (1986). In this paper, there is a speculative attack even if the interest rate elasticity of the consumers' money-demand function equals zero, the reason simply being that both firms and consumers demand money in the present paper. The "natural collapse" can in this paper thus only occur if both consumers *and* firms do not change their money holdings in response to a change in the rate of inflation.

Finally, it is reasonable to mention the most important differences between this paper and the literature on the supply-side theory of ERB stabilization plans as developed in Roldós (1995), Edwards & Végh (1997), Uribe (1997, 2000), and Agénor & Pizzati (2000).⁴ First, this

⁴This is reasonable because it is the assumption that the stabilization plan affects the supply of goods that ultimately drives many of the results of the paper.

paper places a greater focus on the welfare implications of the stabilization plan. Second, the paper models the supply-side effects by assuming a role for money in the process of production whereas Roldós (1995) and Uribe (1997) model their supply-side effects by assuming that investments are subject to liquidity constraints (firms need to hold cash in advance of investing in the capital good needed for production) and Edwards & Végh (1997) assume that firms must use bank credit to pay for labor inputs (firms face a credit-in-advance constraint). Lastly, this paper gives a more detailed description of the speculative currency attack that puts an end to the stabilization plan.

The remainder of the paper is organized as follows. Section 2 describes the behavior of the representative household and the representative firm, and section 3 sets up the “public” sector consisting of the government and the central bank. In section 4, a temporary shock to government transfers is used to briefly illustrate some of the properties of the model. Section 5 provides the analysis of the consequences of the temporary decrease in the rate of devaluation. Section 6 describes the speculative attack on the exchange rate, and a final section discusses some of the assumptions that are made in the paper and gives suggestions for future research.

2 The private sector

In order to keep the model here simple, but detailed enough to illustrate the positive effects on consumption resulting from the stabilization plan, the following assumptions are made. There are three sectors in the economy: the household/firm unit, i.e. the representative consumer owns the representative firm, the government, and the central bank. The economy is a small open economy where the real interest rate is given from abroad as the constant international real interest rate. Leisure is not included as an argument in the utility function, so “full employment” production is secured. Throughout the paper, the size of the population in the economy is assumed to be constant. Aggregation in the model is a straightforward task as all individuals are assumed identical, i.e. it will suffice to study the actions of the representative household/firm unity. There is one internationally traded good, as in Obstfeld (1986), Claessens (1988), Bacchetta (1990), Edwards & Végh (1997), and Daniel (2000), so the firms operate under perfect competition and the real exchange rate remains constant. Finally, the model is deterministic and set in continuous time.

2.1 The household/firm unit

A representative household consumer holds money for two reasons: first, because his utility is increased when he holds money⁵ and, second, because money is needed for the production of goods. Denote by m^C the amount of money from which the consumer derives utility and by m^F the amount of money that the consumer uses for productive purposes in his firm. The individual's total holdings of money is thus $m = m^C + m^F$. In addition to the utility that the consumer derives from holding money, he also derives utility from the consumption of a consumption good c . The consumer lives infinitely and maximizes a utility function of the kind

$$U_0 = \int_0^{\infty} u(c_t, m_t^C) e^{-\theta t} dt, \quad (1)$$

where θ is the individual's constant rate of time preferences. The utility function obeys the standard assumptions, i.e. it is continuously differentiable in each argument and strictly concave ($u_x > 0$ and $u_{xx} < 0$, for $x = c, m^C$). The cross derivatives, u_{cm^C} , will be discussed in section 2.2. Furthermore, $u(x)$ satisfies the assumptions $u(x) \rightarrow -\infty$ for $x \rightarrow 0$, $u_x(x) \rightarrow \infty$ for $x \rightarrow 0$, and $u_x(x) \rightarrow 0$ for $x \rightarrow \infty$ in order to exclude corner solutions.

The individual must decide how much to consume or, equivalently, how much to save. For saving purposes, he can hold real money balances m and a foreign bond b .⁶ The total wealth of the representative individual a is therefore:

$$a_t = m_t + b_t. \quad (2)$$

Another assumption here is that prices are fully flexible and purchasing power parity holds at all times. Since the country is small, changes in domestic variables do not affect the foreign price level. The foreign price level p^f is normalized to one and the exchange rate e will thus equal the domestic price level, $p = e$, and the inflation rate π will measure the rate of currency devaluation, i.e. $\pi = \frac{\dot{e}}{e}$. Notice that the assumption of a fixed foreign price level implies that the foreign real and the foreign nominal interest rates coincide.

⁵Feenstra (1986) discusses in some detail different ways to interpret the utility-providing role of money. Basically, the argument is that the consumer can reduce the amount of time used on the purchase of consumption goods when money is an accepted means of payment in relation to the amount of time he would have to use on purchasing goods if money was not an accepted means of payments, and he had to resort to barter trade.

⁶Obviously, the part of income that is not consumed is saved; such money holdings (whether held for utility-creating or production purposes) are regarded as part of total savings.

Since the individual owns the firm, any pre-tax income he receives derives from the production of goods y . The return from saving in bonds equals $r^f b$, with r^f as the given foreign real interest rate. The consumer receives real lump-sum transfers g from the government. In the general version of the model, the individual pays taxes τ_t out of income. The flow constraint can now be written as

$$\dot{b}_t + \frac{\dot{M}_t}{e_t} = r^f b_t + g + (1 - \tau_t) y_t - c_t, \quad (3)$$

with M as nominal money, or equivalently:

$$\dot{a}_t = r^f b_t + g + (1 - \tau_t) y_t - c_t - \pi_t m_t. \quad (4)$$

Equation (4) shows that the change in real wealth (savings) equals the difference between income and full consumption, where income derives from savings from the previous periods, after-tax income from production, or lump-sum transfers from the government and full consumption is defined by the consumption of goods and money. The direct cost of holding money is the inflation tax paid to the government. A variable without a time subscript in (4) is assumed constant. To set the scene, the paper considers first a simple no-tax economy, i.e. an economy with $\tau_t = 0$. Income taxes will then be reintroduced at a later stage of the analysis.

Production. Following Benhabib *et al.* (2001), it is assumed that the firm uses only real money balances in its production, such that the production of goods is described by a production function with real money balances as the only input:

$$y_t = f(m_t^{\mathcal{F}}). \quad (5)$$

The production function obeys everywhere the restrictions $f' > 0$ and $f'' < 0$, and satisfies also $f' \rightarrow -\infty$ for $m^{\mathcal{F}} \rightarrow 0$ and $f' \rightarrow 0$ for $m^{\mathcal{F}} \rightarrow \infty$.

Why assign money a productive role? Dating back to Sidrausky (1967), it is understood that if money's only role is to provide utility to the consumers in a closed economy, changes in the monetary regime will have no impact on consumption and output. Consequently, a "Sidrausky-like model" cannot explain how a change in the monetary regime can lead to booms in output and consumption when the ERB stabilization plan is implemented; nor can it explain why a recession occurs when the plan is later abandoned. In order to generate such effects, a way around the superneutrality of money must be generated.⁷ This paper finds a way around the

⁷Earlier discussions of the Sidrausky model and the issue of non-neutral money in open economies can be

superneutrality of money by assuming that money plays a role in the production of goods as in Fisher (1974, 1983), Calvo (1979), Gylfason & Herbertsson (1996) and, more recently, Benhabib & Farmer (2000) and Benhabib *et al.* (2001). The basic rationalization of a role for money in the process of production is that money facilitates a firm's transactions such as the purchase and sale of capital used for the production of goods, payments to other factor inputs, transfer of income from the buyers of the goods to the firm, and so forth, see Fisher (1974).⁸ Generally, high inflation implies high alternative costs of holding money. In periods with high inflation, firms are thus less willing to hold money and consequently firms are less prepared to readily carry out these above-mentioned transactions. On the other hand, the assumption that money plays a productive role also implies that if a stabilization plan actually brings down inflation, production will be positively affected.

The problem for the household/firm unit. The problem for the representative household is to find a path $\{c_t, m_t^C, m_t^F\}_{t=0}^{\infty}$ which maximizes (1) subject to (4) and the terminal condition:

$$\lim_{t \rightarrow \infty} a_t \cdot e^{-r^f t} \geq 0. \quad (6)$$

The flow budget constraint (4) can be rewritten as

$$\dot{a}_t = r^f a_t + y_t + g - c_t - (r^f + \pi_t) m_t, \quad (7)$$

and the intertemporal constraint is consequently given by:

$$\int_0^{\infty} [y_t + g - m_t^F (r^f + \pi_t)] e^{-r^f t} dt + a_0 = \int_0^{\infty} [c_t + m_t^C (r^f + \pi_t)] e^{-r^f t} dt. \quad (8)$$

Equation (8) states that the discounted value of future full consumption equals the initial wealth a_0 plus net income accumulated over the life horizon, with net income being real income (arising from government transfers and the production of goods) minus the costs associated with the

found in Obstfeld (1985) and Claessens (1988) both of whom report money to be non-neutral in an open economy if the utility function of the representative consumer is non-separable in consumption and money. As Obstfeld (1985), pp. 622, notes: "For the class of utility functions studied (in his model), the direction of disinflation's expenditure effect hinges on whether the marginal utility of consumption increases or decreases as real balances rise. It is somewhat disturbing that the model's predictions depend so strongly on this sign". For this reason also, the utility function employed in this paper is separable in money and consumption such that the real effects on consumption arise as a consequence of the productive role of money only.

⁸The rationalization of a role for money in the production function of firms thus corresponds closely to the rationalization of a role for money in the utility function of the representative consumer; see Feenstra (1986).

production of goods. In the remaining part of the paper, it is assumed that $a_0 = 0$ for ease of exposition.

Above, the constant variables g and r^f have been identified by the absence of time subscripts; in the following, “ t -subscripts” will be omitted also for the other variables. Maximizing the Hamiltonian $\mathcal{H} = u(c, m^C) + \lambda[r^f b + y + g - c - \pi(m^C + m^F)] + \mu[a - b - m^C - m^F]$, with production given by (5) and λ and μ being the co-state variables associated with the problem, the standard necessary first order conditions are:

$$\frac{\partial \mathcal{H}}{\partial c} = 0 \Rightarrow u'_c = \lambda \quad (9)$$

$$\frac{\partial \mathcal{H}}{\partial m^C} = 0 \Rightarrow u'_{m^C} = \lambda\pi + \mu \quad (10)$$

$$\frac{\partial \mathcal{H}}{\partial m^F} = 0 \Rightarrow \lambda f'_{m^F} = \lambda\pi + \mu \quad (11)$$

$$\frac{\partial \mathcal{H}}{\partial b} = 0 \Rightarrow \lambda r^f = \mu \quad (12)$$

$$\frac{\partial \mathcal{H}}{\partial a} = -\dot{\lambda} + \theta\lambda \Rightarrow \lambda r^f = -\dot{\lambda} + \theta\lambda \quad (13)$$

$$\lim_{t \rightarrow \infty} a_t \lambda_t e^{-\theta t} = 0. \quad (14)$$

As $u(c, m^C)$ is strictly concave and the right-hand-side of (4) is linear and thus concave, these conditions are also sufficient. The equations (9), (10), (11), and (12) correspond to the same kind of first order conditions one gets in a static problem, while (13) and (14) assure that the problem is dynamically consistent.

2.2 The consumer's and the firm's demand functions

Given the first order conditions of the consumer's problem, (9) – (14), it follows that consumption develops over time according to:

$$\frac{\dot{c}}{c} = -\frac{u_c}{u_{cc}c} [r^f - \theta] \quad (15)$$

From (15), it is seen that if the economy is to reach a steady state, the international real interest rate r^f must equal the consumer's rate of time preferences θ . This condition is also economically intuitive. If $r^f < \theta$ and thus $\frac{\dot{c}}{c} < 0$, the consumers in such an hypothetical economy would be less patient than the rest of the world, implying that they would consume relatively more today and thus build up an ever increasing debt thereby eventually breaking with the intertemporal budget constraint of the country. On the other hand, when $r^f > \theta$, the country is more patient than the rest of the world, implying that the country will accumulate

infinitely more assets and will grow without bounds such that the small country asymptotically ends up “owing the whole world”.

2.2.1 The consumer’s demand for consumption and money. In order to obtain closed solutions for the demand functions, a specific utility function is needed. The choice of the form of the utility function is not a trivial matter, though, as the sign of the cross derivative between real money balances and the consumption of goods ($u_{cm}c$) has important implications for the effect on consumption from a reduction in the rate of inflation. For instance, Obstfeld (1985) and Claessens (1988) show that money is neutral only when the utility function is separable in money and consumption. In a model with a non-separable utility function, they find that the sign of the change in consumption depends crucially on whether a rise in real money balances reduces or increases the marginal utility of consumption. In order to get clear results, the utility function used in this paper is assumed to be separable in money and consumption. A standard utility function with the property that $u_{cm}c = 0$ is the logarithmic utility function

$$u(c, m^{\mathcal{C}}) = \alpha \ln c + (1 - \alpha) \ln m^{\mathcal{C}}, \quad (16)$$

for $0 < \alpha < 1$.⁹ The first order conditions (9) and (10) imply that $\frac{u_{m^{\mathcal{C}}}}{u_c} = r^f + \pi$ which given (16) can be written as

$$\frac{c}{m^{\mathcal{C}}} = \frac{\alpha}{1 - \alpha} (r^f + \pi), \quad (17)$$

i.e. consumption is proportional to $m^{\mathcal{C}}$ with the factor $\frac{\alpha}{1 - \alpha} (r^f + \pi)$.

As mentioned, a steady state requires $r^f = \theta$. In this case, (13) implies that the co-state variable λ will be constant over time in the absence of unanticipated shocks, i.e. $\lambda_t = \lambda = \bar{\lambda}, \forall t$.

⁹Of course, the logarithmic utility function is nothing more than a specific member of the class of utility functions that possesses constant relative risk aversion, $u(c, m) = \left([c^\alpha m^{1-\alpha}]^{1-\eta} \right) / (1 - \eta)$, where η is the coefficient of risk aversion, or in this deterministic model, the elasticity of substitution between consumption at two points in time. For $\eta = 1$ one gets the logarithmic utility function.

The assumption of $\eta = 1$ is not considered to be very restrictive as one could easily work with other separable utility functions, such as for instance $u(c, m) = (c^{1-\eta}) / (1 - \eta) + \delta \ln m$. If one did so, the qualitative results in the paper would carry through anyway, the results would just look slightly more complicated due to the resultant non-linearity. If for instance $u(c, m) = (c^{1-\eta}) / (1 - \eta) + \delta \ln m$, consumption would be determined as $c = (r^f V)^\eta$ which can be compared to the linear expression for consumption obtained in the following equation (22). The advantage of working with the logarithmic utility function is thus that it generates simple linear results.

As $u_c = \lambda = \bar{\lambda}$, the logarithmic utility function gives:

$$c = \frac{\alpha}{\bar{\lambda}}. \quad (18)$$

If an unanticipated shock that influences the co-state variable $\bar{\lambda}$ is realized, (18) implies that the demand for the consumption good will be changed. Such a change in c will from (17) change the demand for money also.

In section 2, it was shown that net income accumulated over the life horizon V will equal full consumption:

$$V = \int_0^\infty [y + g - m^{\mathcal{F}}(r^f + \pi)]e^{-r^f t} dt = \int_0^\infty [c + m^{\mathcal{C}}(r^f + \pi)]e^{-r^f t} dt. \quad (19)$$

The proportional behavior of consumption relative to money implies that $c + m^{\mathcal{C}}(r^f + \pi) = \frac{c}{\alpha}$. Substitute this into the budget constraint together with the expression $\frac{c}{c} = \bar{\lambda}$ to obtain:

$$V = \int_0^\infty \left(\frac{1}{\bar{\lambda}}\right) e^{-r^f t} dt. \quad (20)$$

As $\bar{\lambda}$ is constant over time

$$\bar{\lambda} = (r^f V)^{-1},$$

the value of the co-state variable $\bar{\lambda}$ can be given as:

$$\bar{\lambda} = \left[r^f \int_0^\infty (y + g - m^{\mathcal{F}}(r^f + \pi)) e^{-r^f t} dt \right]^{-1}. \quad (21)$$

The expression for the co-state variable given in (21) can be substituted into (18) to find the demand for the consumption of goods

$$c = \alpha r^f V \Rightarrow c = \alpha \left[r^f \int_0^\infty (y + g - m^{\mathcal{F}}(r^f + \pi)) e^{-r^f t} dt \right], \quad (22)$$

and the demand for real money balances

$$m^{\mathcal{C}} = \frac{1 - \alpha}{\alpha} \frac{1}{r^f + \pi} c, \quad (23)$$

where c is given in (22). Equation (22) gives that $c + m^{\mathcal{C}}(r^f + \pi) = r^f V$, so the representative consumer sets full consumption equal to his interest earnings on wealth. This is a general finding of models imposing $r^f = \theta$.

As mentioned in the introduction and seen through (11), the level of production is conditionally determined by the rate of inflation. Together with (23), this dependence implies that several effects are at work when an *unanticipated* change in the inflation rate π is undertaken.

One of the effects is the instantaneous one on the consumer's demand for real money balances, which for constant c is given by:

$$\left. \frac{\partial m^c}{\partial \pi} \right|_{dc=0} = - \left(\frac{1-\alpha}{\alpha} \frac{1}{(r^f + \pi)^2} \right) c < 0. \quad (24)$$

Holding consumption constant, there is thus a clear negative drop in the demand for real money balances. This occurs, of course, because the costs of holding real money increase. However, c will not be constant, because c depends on the future stream of income which in this economy will change. In sum; when the rate of devaluation is decreased, there will not only be the obvious direct effect on the nominal interest rate, but there will also be an indirect effect, as the decrease in inflation causes more money to be used in production, thereby increasing the level of production itself, as shown below.

2.2.2 The demand for money for productive purposes. Before moving on to the description of the government and the analysis of temporary shocks, the amount of money demanded for the production of goods will be determined. The optimal holdings of money are from equation (11) determined by the condition $f'(m_t^{\mathcal{F}}) = r^f + \pi_t$. The production function is assumed to be concave implying that an increase in the rate of devaluation will reduce the firm's demand for money as $\frac{\partial m^{\mathcal{F}}}{\partial \pi} = \frac{1}{f''} < 0$. Consequently, an increase in the rate of devaluation will lower production by the following quantity:

$$\frac{\partial y}{\partial \pi} = f' \frac{\partial m^{\mathcal{F}}}{\partial \pi} = \frac{f'}{f''} < 0. \quad (25)$$

If production is realized according to a logarithmic production function – to remain consistent with the choice of the logarithmic utility function – production will be determined by $y = \gamma \ln m^{\mathcal{F}}$ and money demand will be $m_t^{\mathcal{F}} = \frac{\gamma}{r^f + \pi_t}$. In this case, $\frac{\partial m^{\mathcal{F}}}{\partial \pi} = -\frac{\gamma}{(r^f + \pi_t)^2} < 0$ and production is thus negatively influenced by an increase in inflation as $\frac{\partial y}{\partial \pi} = -\frac{\gamma}{m^{\mathcal{F}}} \left(\frac{\gamma}{(r^f + \pi_t)^2} \right) = -\left(\frac{\gamma}{r^f + \pi_t} \right) < 0$.¹⁰

¹⁰If the production function also included capital, and was non-separable in money and capital, the condition that secures that both capital and money balances are reduced when the rate of inflation is increased (and thus that production unambiguously falls when inflation is increased) is that lower money balances lead to lower capital holdings, and the cross derivative of a non-separable production function including both capital and money balances should thus be positive; see Fisher (1983).

3 The central bank and the government

The final sectors in the economy are the central bank and the government. The distinction between these two sectors is that the government decides on the size of public expenditures and revenues, and consequently decides on whether its budget should be in a deficit position or not. The financial consequences of these decisions of the government are then injected into the economy via the central bank. Furthermore, the government can borrow from the central bank to finance a deficit on its budget.

The central bank controls three assets: R = the foreign exchange reserves denoted at their foreign currency price, M = the nominal money supply, and D = the central bank's credit to the government. The central bank does not borrow from abroad, so gross foreign assets equal net foreign assets. Therefore, nominal central bank profits

$$\mathcal{P} = er^f R + \dot{e}R, \quad (26)$$

arise from interest earnings on the foreign exchange reserves plus the capital gains that result from exchange rate movements. From the balance sheet of the central bank, it follows that the money supply is made up of domestic credit and the domestic currency value of the foreign exchange reserves

$$M_t = D_t + e_t R_t, \quad (27)$$

so the change in the money supply is:

$$\frac{\dot{M}}{e} = \frac{\dot{D}}{e} + \pi R + \dot{R}. \quad (28)$$

The government pays lump sum transfers to the consumers as well as interest payments on its foreign debt. It is assumed that, except for the exchange rate denomination, no differences between domestic and foreign debt/capital exist so the government pays the international real interest rate on its foreign-currency-denominated debt, i.e. the government pays no risk premium on its foreign debt.¹¹

In the general version of the model, the outlays of the government are financed by raising credit from the central bank or from abroad, from income taxes, or from central bank profits.

¹¹Actually, foreign debt plays no essential role in the model and is thus only included for the sake of completeness, i.e. this assumption is in no way crucial.

The government's budget identity in nominal terms is thus

$$eg + er^f F = \dot{D} + \mathcal{P} + e\dot{F} + \tau ye, \quad (29)$$

with F being the foreign debt denoted at its foreign currency value. Expressing the budget identity in real terms and inserting the real profits from (26) as well as the change in nominal credit deflated by the price level from (28) gives

$$g + r^f F = \dot{F} + \dot{m} + \pi m + \tau y - \dot{R} + r^f R, \quad (30)$$

where the change in the deflated nominal money supply $\frac{\dot{M}}{e}$ is expressed as $\dot{m} + \pi m$ with m as the real money supply. The left-hand side of (30) reveals the government's expenditures (transfers and interest payments on the foreign debt), whereas the right-hand side reveals the government's revenues (issues of new debt, seigniorage, income taxes, sales of foreign exchange reserves, and interest revenues from foreign exchange reserves). In order to keep matters simple, it is in the following part of the paper assumed that any deficit in the government budget is financed solely by money creation, i.e. income taxes are zero ($\tau = 0$) and the foreign debt does not increase ($\dot{F} = 0$). Income taxes will then be reintroduced at a later stage of the analysis.

Because the government will borrow from the central bank if there is a deficit in the government budget, such a deficit will affect the foreign exchange reserves and thereby the central bank's ability to intervene on the foreign currency market. In particular, the path of foreign exchange reserves is determined as:

$$\dot{R} = [\dot{m} + \pi m] - [g + r^f(F - R)]. \quad (31)$$

Of course, (31) implies that if $[\dot{m} + \pi m] < [g + r^f(F - R)]$, foreign exchange reserves will shrink - an insight that is crucial for the understanding of the speculative currency attack described later in the paper.

In line with the speculative currency attack literature, begun by Krugman (1979), it is assumed that R cannot fall below some lower boundary. The lower boundary is assumed to equal 0 (but could take on any value, \bar{R}), so:

$$R_t \geq 0, \forall t. \quad (32)$$

Even when the assumption of a lower boundary on R is standard, it is appropriate to recapitulate two reasons why such a boundary could exist. First, Obstfeld (1986) shows that the government's intertemporal budget constraint is violated if the rate of domestic credit

expansion exceeds the international real interest rate, i.e. the restriction in (32) can be seen as a substitute for the assumption that the growth rate of domestic credit exceeds the international given real interest rate. Second, Willman (1991) shows, in a somewhat different model, that when net foreign reserves are below zero, a welfare loss is realized.

3.1 Government revenues and the exchange rate regime

The choice of an exchange rate regime restricts the behavior of some of the variables appearing on the central bank's balance sheet and therefore restricts some of the government's revenues as well. In the following sections, it is shown how.

3.1.1 The government's budget constraint under floating exchange rates. The budget constraint of the government will reveal whether the fixed exchange rate policy is maintainable over a longer period of time or not. In this paper, as in traditional first-generation models, it is assumed that nominal domestic credit grows at a constant rate σ , so $\frac{\dot{D}}{D} = \sigma$. Denote real domestic credit as D^R . It follows that $\frac{\dot{D}}{e} = \dot{D}^R + D^R\pi = \sigma D^R \Rightarrow \dot{D}^R = D^R(\sigma - \pi)$, or in other words that in a steady state in a floating exchange rate regime

$$\sigma = \pi, \tag{33}$$

and the rate of inflation will equal the rate of growth of domestic credit.

In a floating exchange rate regime, the central bank does not intervene in the foreign exchange market and foreign exchange reserves therefore remain constant $\dot{R} = 0$. Constant foreign exchange reserves imply from (28) that $\left(\frac{\dot{M}}{e}\right) = \left(\frac{\dot{D}}{e}\right) + \pi R$. Therefore, the budget constraint of the government turns out to be:

$$g + r^f (F - R) = \frac{\dot{M}}{e} + \pi R = \dot{m} + \pi m + \pi R. \tag{34}$$

A careful scrutinizing of (34) reveals how lump-sum transfers g are influenced by the current exchange rate system. Lump-sum transfers are financed by interest earnings on net foreign assets, by capital gains arising from changes in the exchange rate, and from the changes in money that arise from changes in domestic credit:

$$g = \dot{m} + \pi m + \pi R - r^f (F - R).$$

As capital gains and interest earnings from the foreign exchange reserves help to finance government transfers, a loss of foreign exchange reserves will have an impact on how much the

government is able to transfer to the consumers. In particular, as foreign exchange reserves are zero (in this model) after the temporary exchange-rate-based stabilization plan has broken down, $R_{t \geq T} = \dot{R}_{t \geq T} = 0$ with T as the point in time where the stabilization plan breaks down, government transfers need to be reduced to

$$g^* = \dot{m} + \pi m - r^f F, \quad (35)$$

as a consequence of the breakdown of the plan. Notice how g^* is strictly lower than the transfers that the government could have made to the consumers had there been no loss of foreign exchange reserves.

Finally, it is observed that $\left(\frac{\dot{D}}{e}\right) = \left(\frac{\dot{M}}{e}\right)$ after the breakdown of the stabilization plan, i.e. any constant growth of domestic credit $\frac{\dot{D}}{D} = \sigma$ will give rise to a constant growth of nominal money $\frac{\dot{M}}{M} = \sigma$, which from (33) will equal the rate of devaluation.

3.1.2 The government's budget constraint under managed exchange rates. In periods when the exchange rate is managed (such as during an ERB plan), the central bank is ready to intervene in the foreign exchange market and foreign exchange reserves are not necessarily fixed.¹² Changes in the foreign exchange reserves will now influence the money supply, as (28) reveals that $\left(\frac{\dot{M}}{e}\right) = \left(\frac{\dot{D}}{e}\right) + (\pi R + \dot{R})$. The government budget constraint under managed exchange rates will be given by (30) and the changes in foreign reserves are thus given as $\dot{R} = \left(\frac{\dot{M}}{e}\right) - [g + r^f(F - R)]$. Using the identity from the balance sheet of the central bank to substitute $\left(\frac{\dot{M}}{e}\right) - \dot{R} = \left(\frac{\dot{D}}{e}\right) + \pi R$ into the government's budget constraint gives $\left(\frac{\dot{D}}{e}\right) + \pi R = g + r^f(F - R)$ which can be plugged into (31) yielding

$$\dot{R} = \dot{m} + (\pi - \sigma) D^R, \quad (36)$$

after using the fact that $m - R = D^R$. (36) reveals that three variables determine the development in the foreign exchange reserves: the path of real money, the rate of devaluation, and the rate of change in nominal credit. Different forces govern the path of these three variables: the rate of change in nominal credit σ is directly controlled by the government, the rate of devaluation π is directly controlled by the government when the level of foreign exchange reserves is sufficient, and the path of money \dot{m} is determined by the equilibrium on the money market.

¹²Here, a managed exchange rate regime is defined as a regime where the central bank uses its foreign exchange reserves to maintain a certain value of the exchange rate in each period of time and where it is thus not necessarily the case that the rate of growth of domestic credit equals the rate of devaluation.

The choice of the exchange rate regime has a profound influence on the demand for money which again influences the supply of money in equilibrium. It follows from the discussion in section 2.2 that when exogenous variables, and especially π , are constant, the demand for c , m^C , and m^F are constant:

$$\dot{m}|_{dc=0} = \dot{m}^F|_{dc=0} \dot{m}^F + \dot{m}^C|_{dc=0} = 0. \quad (37)$$

Consumption and holdings of real money balances are thus only changed when π is changed. Equating the change in the money supply from (31) with the change in the money demand from (37), it follows that in periods where $\Delta\pi = 0$:

$$\dot{R} = (\pi m + r^f R) - (g + r^f F). \quad (38)$$

The constant demand for money thus limits the available revenues from seigniorage and the only sources of income to the government are the proceeds from the inflation tax and the interest earnings on the foreign exchange reserves.

Changes in the exchange rate regime and the path of foreign exchange reserves.

It follows from (38) that there will be a $\tilde{\pi}$ for which $\tilde{\pi}m = [g + r^f(F - R)] \Leftrightarrow \dot{R} = 0$, i.e. in this steady state, foreign exchange reserves are constant also, $\dot{R} = 0$, and $\pi = \tilde{\pi} = \sigma$. It also follows that whether or not foreign exchange reserves are depleted when the rate of devaluation is reduced depends on what happens to the inflation tax πm . In other words, if money holdings remain constant (which they do not, however, as will be shown below) when the rate of devaluation is changed, there will be some $\bar{\pi} < \tilde{\pi}$ for which $\bar{\pi}m < [g + r^f(F - R)] \Leftrightarrow \dot{R} < 0$, i.e. a depletion of reserves is realized. In this last situation (with $\bar{\pi} < \tilde{\pi}$), a managed exchange rate policy is impossible to maintain infinitely when a lower bound on R is present. If, on the other hand, money holdings change as the rate of devaluation is changed, some ambiguity is added to the relation between changes in the exchange rate regime, the inflation tax, and the path of foreign exchange reserves. To better understand the effects on the foreign exchange reserves when the exchange rate regime is changed, it is thus necessary to understand what happens with the overall demand for money.

Both firms and consumers demand money. It is relatively straightforward to sign the effects from changes in π on the revenues from the inflation tax levied on firms' money holdings. As $m^F = \frac{\gamma}{r^f + \pi}$, the inflation tax levied on firms' holdings of money is $\pi m^F = \frac{\pi\gamma}{r^f + \pi}$. A reduction in the rate of devaluation thus lowers the proceeds from the inflation tax because $\frac{\partial \pi m^F}{\partial \pi} = \frac{\gamma r}{(r^f + \pi)^2} > 0$.

Signing what happens with the proceeds from the inflation tax levied on the consumers' holdings of money is somewhat more complicated. As $m^C = \frac{1-\alpha}{\alpha} \frac{1}{r^f + \pi} c$, $\pi m^C = \frac{1-\alpha}{\alpha} \frac{\pi}{r^f + \pi} c$, and:

$$\frac{\partial \pi m^C}{\partial \pi} = \frac{1-\alpha}{\alpha} \frac{1}{r^f + \pi} \left[\left(\frac{r^f}{r^f + \pi} \right) c + \left(\frac{\pi}{r^f + \pi} \right) \frac{\partial c}{\partial \pi} \right] \Rightarrow \begin{cases} \frac{\partial \pi m^C}{\partial \pi} > 0 & \text{for } \frac{\partial c}{\partial \pi} > 0 \\ \frac{\partial \pi m^C}{\partial \pi} \leq 0 & \text{for } \frac{\partial c}{\partial \pi} < 0 \end{cases} \quad (39)$$

The first term in the square brackets of (39) is unambiguously positive whereas the second term depends on the sign of $\frac{\partial c}{\partial \pi}$ (the effect on consumption when the rate of devaluation is changed) which, as will be extensively discussed in the following sections, can be both positive and negative. In the following sections, it will be shown that if $\frac{\partial c}{\partial \pi} < 0$, the utility of the representative consumer will be increased when the ERB stabilization plan is implemented, whereas if $\frac{\partial c}{\partial \pi} > 0$, the utility of the representative consumer will be reduced. If the government introduces the ERB stabilization plan because it wants to increase welfare, the effects on the revenues from the inflation tax will thus in principle be unclear as the consumers increase consumption and thereby increase the inflation tax base, but the tax rate itself is reduced leaving the effect on the inflation tax ambiguous.

In order to keep the model comparable to the traditional first-generation currency crises models of Krugman (1979) and Flood & Garber (1984), as well as to the utility-maximizing-framework extensions thereof in Obstfeld (1986), Claessens (1988), Bacchetta (1990), Edwards & Végh (1997), and Daniel (2000), it is assumed that the total proceeds from the inflation tax will be reduced if the government reduces the rate of devaluation. In other words, if inflation is reduced from $\tilde{\pi}$ to $\bar{\pi}$, $\bar{\pi}m < [g + r^f(F - R)]$ such that $\dot{R} < 0$ and exchange reserves are depleted. It should be mentioned that this assumption is justifiable not only because it is the “standard” assumption in the literature, but also for the following reasons: (i) the model predicts that the proceeds from the inflation tax on the existing tax base are reduced (as the first term in the brackets of (39) reveals), (ii) the revenues from the inflation tax levied on firms' money holdings are reduced, and (iii) there is empirical evidence that implementations of ERB stabilization plans are associated with falling foreign exchange reserves as mentioned in the introduction to the paper.

3.2 The current account

To complete the description of the economy, the determination of the current account should be reviewed. To this, it is first noted that any surplus or deficit on the current account will be mirrored in an off-setting path of the country's holdings of net foreign assets. Denote by \mathcal{Z} the

total holdings of net foreign assets in this economy. \mathcal{Z} is thus made up of private sector holdings of foreign bonds as well as public sector net holdings of foreign bonds, i.e. $\mathcal{Z} = b + R - F$. With $b = a - m$ and $\dot{F} = 0$, (7) together with (31) and the definition of \mathcal{Z} give

$$\dot{\mathcal{Z}} = r^f \mathcal{Z} + y - c,$$

i.e. the change in net foreign assets of the country equals the trade balance plus interest payments on the net foreign assets “as should be the case in any well-defined open-economy model” to quote Calvo (1987), pp. 24.

4 Temporary shocks

To illustrate some of the properties of the model, this section briefly analyzes a situation in which there is a temporary shock to government expenditures. The analysis will have some parallels to other investigations of temporary policy changes in small open economies, such as those by Obstfeld (1983) and Sen & Turnovsky (1989) who study a situation where the terms of trade are temporarily changed and Sen & Turnovsky (1990) who study the case of a temporary tax credit. In a more formal setting, Giavazzi & Wyplosz (1985) analyze temporary policy adjustments that have permanent effects. In section 5, the effects of the temporary ERB-stabilization plan are then described.

It follows from the analysis in section 2.2 that the constancy of the co-state variable plays an important role when analyzing the effects of policy changes on the endogenous variables. Especially, when no unanticipated shocks occur:

$$\bar{\lambda} = \left[y + g - m^{\mathcal{F}}(r^f + \pi) \right]^{-1}. \quad (40)$$

Assume now that an *unanticipated* temporary drop in government transfers is realized. Especially, in period $t = 0$, g drops from g to g' and remains at this level until period T , where it is known to return to g and remain at this level forever.¹³ Because the shock is unexpected,

¹³In order keep the story simple, it is assumed that the representative consumer does not expect the government to accumulate assets in periods between period $t = 0$ and $t = T$ even when the government’s revenues do not change. Consequently, the consumer does not expect government expenditures to be higher than g in periods $t \geq T$. One way to think of this could be that the government for instance plans to increase payments to foreign countries for a limited period of time - foreign aid etc. In essence, the temporary drop in government expenditures thus substitutes a temporary shock to real income that does not arise as a consequence of the change in inflation.

$\bar{\lambda}$ jumps in period $t = 0$ to:

$$\bar{\lambda}' = \left(\frac{1}{r^f} \right) \left[\int_0^\infty \{y - m^{\mathcal{F}}(r^f + \pi)\} e^{-r^f t} dt + \int_0^T g' e^{-r^f t} dt + \int_T^\infty g e^{-r^f t} dt \right]^{-1}. \quad (41)$$

The rest of the variables are assumed to remain constant. Since π and r^f are constant, $m^{\mathcal{F}}$ will also be constant so that changes in g do not influence the decisions of the firms, i.e. y is not influenced by the change in g and (41) becomes:

$$\bar{\lambda}' = \left[y - m^{\mathcal{F}}(r^f + \pi) + g'(1 - e^{-r^f T}) + g e^{-r^f T} \right]^{-1}. \quad (42)$$

In order to investigate the sign of $(\bar{\lambda}' - \bar{\lambda})$ it suffices to analyze whether g is larger than $g'(1 - e^{-r^f T}) + g e^{-r^f T}$. As $g > g'$

$$\bar{\lambda}' > \bar{\lambda}, \quad (43)$$

implying that an unanticipated drop in the level of government transfers increases the co-state variable at the same instant in time as the change in fiscal policy is realized. This lowers the level of consumption and the demand for real money balances. The unanticipated *temporary* change in government transfers has thus *permanent* real effects as the flat consumption profile is changed immediately in response to the shock.

Because the increase in government transfers at time T is expected by the households, there is no change in the representative individual's demand patterns at time T . Basically, the representative household has taken the change at $t = T$ into account when deciding on the consumption pattern after the change in government transfers at time $t = 0$. This also implies that *if* the drop in government transfers (at $t = 0$) was indeed foreseen by the consumer, i.e. if the change was anticipated, there would be *no* change in the demand patterns.

5 The temporary exchange-rate-based stabilization plan

Assume now that the government finds that the rate of devaluation is too high and thus instructs the central bank to reduce the rate of devaluation; in the following this is called “the implementation of an exchange-rate-based stabilization plan”. It is assumed that this implementation of the ERB plan is an unexpected event, i.e. that the private sector is unable to foresee the reduction in the rate of devaluation before it is actually realized. This is the only departure from the perfect foresight environment that will be allowed in the model.¹⁴

¹⁴This departure from the perfect foresight environment is the standard way of modelling the implementation of temporary ERB plans in the literature.

In the introduction to the paper, it was mentioned that the stabilization plan is known to be temporary only. The reason why this is so is that the part of government revenues which is due to seigniorage is lost when the rate of devaluation is reduced. In particular, in section 3.1.2 it was assumed that when inflation is low, government expenditures are larger than government revenues and foreign exchange reserves are continuously being lost. Because of the limited reserves, $R_t \geq 0 \forall t$, there will be a unique point in time where all reserves are lost. The formal way to determine this point in time, and the associated speculative attack, will be described in section 6, but the implication of losing all of the foreign exchange reserves is obviously that the government can no longer keep the exchange rate fixed and the ERB plan breaks down. In order to finance government transfers after the breakdown of the ERB plan, the government increases the rate of inflation to a level consistent with the fiscal policy requirements of the government.

In short: at time $t = 0$ inflation is reduced, without anticipation, from π_0 to π_1 , and at time $t = T$ increased again, with anticipation, to its original level π_0 , i.e. inflation follows a path as illustrated in Figure 1.

[INSERT FIGURE 1 ABOUT HERE]

As the rate of time preferences equals the real interest rate, $\theta = r^f$, both consumption and money holdings remain constant in periods when there are no changes in the rate of devaluation. In order to study the consequences of the stabilization plan for the utility of the consumer, it is thus enough to study what happens with utility at the points in time where the rate of devaluation is changed.

5.1 The effects of the stabilization plan on consumption and money holdings

Prior to the implementation of the stabilization program, the agents expect all variables to remain constant, and consumption and money holdings are given by:

$$c_0 = \alpha \left[r^f \int_0^\infty \left\{ y_0 + g - m_0^{\mathcal{F}} (r^f + \pi_0) \right\} e^{-r^f t} dt \right] \quad (44)$$

$$m_0^{\mathcal{C}} = \left(\frac{1 - \alpha}{\alpha} \frac{1}{r^f + \pi_0} \right) c_0 \quad (45)$$

$$m_0^{\mathcal{F}} = \frac{\gamma}{r^f + \pi_0}. \quad (46)$$

At time $t = 0$, the rate of devaluation is reduced to $\pi_1 < \pi_0$. If production was *not* dependent on the rate of devaluation, there would be no change in consumption associated with the change

in π as the cross elasticity of the utility function equals zero in this model with a separable utility function. However, in this model, production is indeed dependent on the rate of devaluation as money holdings used for productive purposes are changed when π is changed. In particular, (25) revealed that production is increased when the rate of devaluation is reduced. This implies that production increases from y_0 to $y_1 > y_0$ at time $t = 0$ as money holdings increase from $m_0^{\mathcal{F}}$ to $m_1^{\mathcal{F}} > m_0^{\mathcal{F}}$. Furthermore, as the stabilization program is known to end at time $t = T$, the consumers know that after time $t = T$, production returns to its original level $y_T = y_0$ as money holdings return to $m_T^{\mathcal{F}} = m_0^{\mathcal{F}}$.¹⁵ Finally, section 4 showed that only unanticipated changes in income will make consumption change, i.e. consumption will only change in period $t = 0$, and thus remain constant at time $t = T$. Taken together, the result of these effects is that consumption will be determined as

$$\hat{c} = \left(\frac{\alpha}{r^f}\right) \left[\int_0^T \left\{ y_1 + g - m_1^{\mathcal{F}}(r^f + \pi_1) \right\} e^{-r^f t} dt + \int_T^\infty \left\{ y_T + g^* - m_T^{\mathcal{F}}(r^f + \pi_0) \right\} e^{-r^f t} dt \right], \quad (47)$$

after period $t = 0$, with $g^* < g$ given by (35). As (24) showed, money holdings change when π is changed (even when consumption does not change), i.e. after the implementation of the stabilization plan, the holdings of money that provide utility are given by

$$m_1^{\mathcal{C}} = \left(\frac{1 - \alpha}{\alpha} \frac{1}{r^f + \pi_1} \right) \hat{c} \quad \text{for } 0 < t < T \quad (48)$$

$$m_T^{\mathcal{C}} = \left(\frac{1 - \alpha}{\alpha} \frac{1}{r^f + \pi_0} \right) \hat{c} \quad \text{for } t \geq T, \quad (49)$$

with \hat{c} being the level of consumption in time periods $t > 0$ as shown in (47).

Using (44) and (47), the levels of consumption before and after time period $t = 0$ are

$$c_0 = \alpha \left[y_0 + g - m_0^{\mathcal{F}}(r^f + \pi_0) \right] \quad (50)$$

$$\hat{c} = \alpha \left[\left(1 - e^{-r^f T}\right) \left\{ y_1 + g - m_1^{\mathcal{F}}(r^f + \pi_1) \right\} + \left\{ y_T + g^* - m_T^{\mathcal{F}}(r^f + \pi_0) \right\} e^{-r^f T} \right], \quad (51)$$

where it is noted that $y_0 = y_T$ and $m_T^{\mathcal{F}} = m_0^{\mathcal{F}}$. Whether consumption increases or not from the lowering of inflation can be seen from the inspection of $\hat{c} - c_0$ which equals:

$$\hat{c} - c_0 = \alpha \left(1 - e^{-r^f T}\right) \left[(y_1 - y_T) - \left\{ m_1^{\mathcal{F}}(r^f + \pi_1) - m_0^{\mathcal{F}}(r^f + \pi_0) \right\} \right] - \alpha e^{-r^f T} (g - g^*).$$

Using the logarithmic production function, the change in consumption turns out to be:

$$\hat{c} - c_0 = \alpha \left(1 - e^{-r^f T}\right) \gamma \ln \left(\frac{r^f + \pi_0}{r^f + \pi_1} \right) - \alpha e^{-r^f T} (g - g^*). \quad (52)$$

¹⁵The model thus generates an initial boom and a later contraction in real output.

5.1.1 Interpretation of (52). (52) is an important equation. It consists of two parts: The first part shows what happens with money holdings and output as a consequence of the ERB plan, and this part is unambiguously positive. The second part reveals how consumption is affected by the reduction in government transfers due to the lost interest earnings and capital gains from the foreign exchange reserves, and this part is unambiguously negative. No matter the signs, however, both terms depend on the duration of the temporary stabilization plan in the following intuitive way: The longer is the stabilization plan, the less counts the reduction in government transfers. In the limit, when the duration of the stabilization plan gets very large (the temporary stabilization plan approaches a permanent stabilization plan)

$$\lim_{T \rightarrow \infty} (\hat{c} - c_0) = \alpha\gamma \ln \left(\frac{r^f + \pi_0}{r^f + \pi_1} \right) > 0,$$

and there is an unambiguously positive effect on the level of consumption. On the other hand, and equally important, if the stabilization plan is expected to break down very fast, then

$$\lim_{T \rightarrow 0} (\hat{c} - c_0) = -\alpha (g - g^*) < 0,$$

and there is an unambiguously *negative* effect on the level of consumption. These results are intuitive: If the interests and capital gains that are earned on the foreign exchange reserves are important determinants of how much can be transferred from the government to the consumers, and these transfers need to be reduced if the foreign exchange reserves are lost in an unsuccessful attempt to defend a managed exchange rate regime, then the shorter the period where the consumers have to live with the reduced transfers, the higher will the likelihood be that utility is increased as a result of the implementation of the stabilization plan. In other words, if the agents in the economy believe that the stabilization plan will remain for a sufficiently long period of time, the resulting reduction in transfers will not hurt the consumers a lot and there will be a positive increase in consumption.

5.1.2 A policy that makes temporary ERB stabilization plans consumption enhancing. One issue has been swept under the rug in the simple model analyzed above: There have been no income taxes. This points towards an interesting new way of conducting policy during a temporary ERB stabilization plan. In the previous section it said: “If interest earnings and capital gains from foreign exchange reserves are *important determinants* of how much can be transferred from the government to the consumers” then the duration of the ERB plan becomes important. Why is this important to notice? Because governments can normally finance transfers using others sources of income, such as income taxes.

When governments can rely on income taxes to finance transfers, there can be situations where it would be reasonable to change the prevailing tax structure in the following way when the ERB plan is implemented: Levy taxes on part of the initial boom in output, save these “excess” tax revenues, and use them and the interest earnings therefrom to finance the revenues lost in a defense of the managed exchange rate regime. If the government taxes income in the interim period when the ERB stabilization plan is effective, it could set taxes such that:

$$\int_0^T \{\tau y_1\} e^{-r^f t} dt = \int_T^\infty \{g - g^*\} e^{-r^f t} dt. \quad (53)$$

In this case, the taxes that are raised during the stabilization plan can be used to finance the costs associated with the abandoning of the plan, and there need not be a reduction in government transfers after the breakdown of the plan.

It is important to notice that if this policy should be welfare-improving, taxes should be set such that the after-tax income earned during the stabilization plan is strictly higher than the income that was earned before the implementation of the plan

$$y_0 < (1 - \tau) y_1, \quad (54)$$

or in other words, it is only be the increase in income $(y_1 - y_0)$ that should be partly taxed. If both conditions (53) and (54) hold, the temporary ERB stabilization plan will be welfare-enhancing, as the change in consumption will be determined by

$$\hat{c} - c_0 = \alpha \left(1 - e^{-r^f T}\right) [(1 - \tau) y_1 - y_T], \quad (55)$$

which is unambiguously positive because $(1 - \tau) y_1 > y_T = y_0$ due to (54).

Discussion. How likely is it that both conditions (53) and (54) are satisfied? Starting with (54), the empirical evidence indicates that this restriction is probably not too difficult to fulfill: When implementations of ERB plans are associated with increases in output – which is normally the case – there is indeed room to increase taxes and still keep after-tax income higher during the interim period than before the implementation of the plan. What about (53)? Is it possible to raise taxes such that they cover the lost future earnings from the foreign exchange reserves? The answer to this question obviously depends on the relative importance of revenues raised from taxes and from foreign exchange reserves. In particular, in countries where the interest earnings and capital gains from the foreign exchange reserves are not very important for financing government expenditures, it is likely that increases in taxes during the plan can

balance out the lost future earnings from the foreign exchange reserves. And, of course, on the other hand, in countries where the revenues being generated from the foreign exchange reserves are of a considerable size, it seems less likely that taxes can be raised so much that they cover the lost revenues. Whether both conditions (53) and (54) are satisfied thus has to be evaluated on a country-by-country basis. It is essential to point out, however, that exactly because there can be situations where both conditions (53) and (54) are satisfied, there can also be situations where ERB plans that without a change in the prevailing tax structure would be decremental to economic welfare can be made welfare-improving.

Is such a plan then possible to implement empirically? As mentioned in the introduction, there is actually an empirical variant, if perhaps not very well-known, of such a kind of policy. In October 1996, Finland joined the Exchange Rate Mechanism of the European Monetary System with the overall goal of joining the third phase of the European Monetary Union and thereby replacing the national legal tender in Finland, the Finnish markka, with the euro. As is well-known, this happened on January 1, 2001. What is perhaps less known is that before giving up the national currency, Finland introduced the so-called “buffer funds”. The idea with these funds was to build up financial reserves during good times, and then use the savings in the funds to reduce wage costs in the event of negative macroeconomic shocks and thus reduce the impact of such shocks. In greater detail, the idea was that when the nominal wages that workers receive are downwards sticky, the only way to reduce wage cost is to reduce the wages paid by the firms. One way to reduce the wages paid by firms can be to reduce the social security contributions that firms pay. Indeed, this is the way the “buffer funds” work in Finland. The firms pay to the funds during good times, and get their social security contributions reduced during bad times, thereby leaving employment and output less affected by adverse macroeconomic shocks.¹⁶ The Swedish government too has discussed introducing the same kinds of funds (Ministry of Finance, Sweden, 2002), concluding that “a system of buffer funds could increase the economy’s ability to adjust, thereby helping to moderate cyclical fluctuations”. In a general sense, the message contained in conditions (53) and (54) is nothing more than a variant of the ideas pursued in Finland: Save funds in goods times (during the ERB stabilization plan) and rely on those funds during bad times (after the breakdown of the plan).¹⁷

¹⁶Holm *et al.* (1999) describe in detail the merits of the Finnish “buffer funds” and estimate the needed sizes of the funds given the history of the Finnish economy and its vulnerability to asymmetric shocks.

¹⁷As a final remark on the Finnish funds, it should be mentioned that the idea in Finland was not so much

What if there are no future “bad times”, i.e. no exchange rate crisis that comes along to put an end to the ERB plan? In this case, the funds are obviously still there, i.e. the funds are just savings piled up. Alternatively, if there is no need for the funds because of a negative shock to the economy, the funds, and the interest earnings and capital gains therefrom, can simply be transferred back to the economy, leaving the economy better off.

The change in the tax structure is one new way to analyze how to reduce the costs associated with breakdowns of ERB stabilization plans. Other authors, for instance Drazen & Helpman (1988, 1989), have studied alternative ways of prolonging the period during which the stabilization plan is effective, but have not detailed the consequences for economic welfare. For instance, could the government reduce the rate at which domestic credit is expanded (reducing σ), this would prolong the period during which the plan is effective.¹⁸ The reason for focusing on the policy of the change in the tax structure and the building up of buffer-funds is inspired by the empirical evidence: As mentioned in the introduction, it is simply often the case that when a country tries to bring down inflation by pegging their exchange rate to that of an anchor country, this ends in a currency crises, and new ways to make such arrangements work better might be interesting to evaluate.

5.2 The change in utility at time $t = T$

Returning to a more formal analysis of the effects on utility from the temporary ERB plan, it is recalled that section 4 showed that when a temporary shock to government transfers is realized, the consumer keeps utility constant from time $t = 0$ and on by leaving demand unadjusted at any time $t > 0$, and thus also at time $t = T$. This is not the case when the rate of devaluation is changed. To illustrate this, consider the level of utility $u(c, m^c) = \alpha \ln c + (1 - \alpha) \ln m^c$. When substituting for the level of c and m^c , the level of utility is at all times given by the

that the funds could be used to reduce costs if abandoning the fixed exchange rate policy (Finland was about to introduce the euro, i.e. Finland did not imagine that the ultimate form of a fixed exchange rate - a common currency - would be abandoned). More, the idea was that Finland would lose the exchange rate instrument that otherwise could be used to stabilize the economy if affected by an asymmetric shock, and therefore other instruments should be set up. Nevertheless, what is important to notice is that the idea was to build up financial reserves in good times of fixed exchange rates and rely on these in bad times.

¹⁸In the same line of reasoning, the government could of course also use the taxes raised during the period where the plan is effective to pay for its transfers (instead of building up buffer-funds) such that the date at which the attack occurs is postponed and, again, one could calculate the conditions related to the size of the tax rate during the stabilization plan needed to make the plan utility enhancing.

indirect utility function:

$$u(c, m^C) = \alpha \ln \left(\frac{\alpha}{\bar{\lambda}} \right) + (1 - \alpha) \ln \frac{1 - \alpha}{\bar{\lambda}(r^f + \pi)}. \quad (56)$$

Unanticipated changes in inflation are seen to influence utility both directly by changing the denominator of the right-hand side of (56) and indirectly through changes in $\bar{\lambda}$. It is also seen that instantaneous utility will not change at time $t = T$ in response to an anticipated change in for instance g as $\bar{\lambda}$ will not be changed at $t = T$, but will indeed change in response to a change in π . The instantaneous change in utility due to an increase in π at $t = T$ is:

$$\frac{\partial u(c, m^C)}{\partial \pi} = - \frac{(1 - \alpha)}{m^C} \frac{(1 - \alpha)}{\bar{\lambda}(r^f + \pi)^2} < 0. \quad (57)$$

At time $t = T$ there is thus an unambiguous negative drop in utility. The reason is that at time $t = T$ only a negative change in m^C is realized, whereas at time $t = 0$ both m^C and the demand for the consumption good are affected by the change in the rate of devaluation.¹⁹

5.3 The change in overall utility

Labelling the instantaneous level of utility in time periods before the implementation of the exchange-rate based stabilization plan as u_0 and instantaneous utility in the interim period where the stabilization plan is effective as u_1 , the change in utility at time $t = 0$ is given by:

$$\begin{aligned} u_1 - u_0 &= \alpha [\ln \hat{c} - \ln c_0] + (1 - \alpha) [\ln m_1^C - \ln m_0^C] \Rightarrow \\ u_1 - u_0 &= \alpha \ln \left(\frac{\hat{c}}{c_0} \right) + (1 - \alpha) \ln \left(\frac{(r^f + \pi_0) \hat{c}}{(r^f + \pi_1) c_0} \right). \end{aligned} \quad (58)$$

Whether $u_1 - u_0$ is positive or negative solely depends on whether consumption is increased or not as a consequence of the introduction of the stabilization plan, as discussed in the interpretation of equation (52).

Labelling instantaneous utility after the breakdown of the stabilization plan as u_T , the change in utility at time $t = T$ is given as:

$$\begin{aligned} u_T - u_1 &= \alpha [\ln \hat{c} - \ln \hat{c}] + (1 - \alpha) [\ln m_T^C - \ln m_1^C] \Rightarrow \\ u_T - u_1 &= (1 - \alpha) \ln \left(\frac{(r^f + \pi_1)}{(r^f + \pi_0)} \right) < 0. \end{aligned} \quad (59)$$

¹⁹Of course, at time $t = T$ also m^F and production change, but these changes do not influence utility at time $t = T$ as they have already been taken into account by the change in consumption at time $t = 0$ as can be seen from (51).

The two effects together give the aggregate change in utility

$$\begin{aligned}
(u_1 - u_0) + (u_T - u_1) &= \alpha \ln \left(\frac{\hat{c}}{c_0} \right) + (1 - \alpha) \ln \left(\frac{(r^f + \pi_0) \hat{c}}{(r^f + \pi_1) c_0} \right) \\
&\quad + (1 - \alpha) \ln \left(\frac{(r^f + \pi_1)}{(r^f + \pi_0)} \right) \Rightarrow \\
(u_1 - u_0) + (u_T - u_1) &= \ln \left(\frac{\hat{c}}{c_0} \right), \tag{60}
\end{aligned}$$

and, again, the consequences for utility depend on whether \hat{c} is larger, smaller, or equal to c_0 . If the temporary ERB stabilization plan is expected to last sufficiently long, or the plan is associated with a change in the tax structure such that both equations (53) and (54) hold, the aggregate utility of the consumer is increased by the temporary reduction in the rate of devaluation, even when utility drops at $t = T$. If these last conditions are satisfied, the pre-stabilization-plan level of life-time utility $U_0 = \int_0^\infty u_0 e^{-\theta t} dt$ is increased to $\hat{U} = \int_0^T u_1 e^{-\theta t} dt + \int_T^\infty u_T e^{-\theta t} dt$ as a consequence of the introduction of the stabilization plan, and life-time utility is positively influenced by the exchange-rate-based stabilization plan.

5.4 Capital flows and the trade balance

Before concluding on the discussion of the real effects of the temporary ERB stabilization plan, the effects on the trade balance and the path of private sector holdings of foreign bonds should be discussed. Consider the effects on the trade balance first. To understand how the trade balance responds to the ERB stabilization plan, note that (47) reveals how consumption does not change at time $t = T$ where production declines, while (52) reveals the change in consumption at time $t = 0$. As discussed, (52) can be both positive and negative, but no matter its sign, consumption is changed by less than production at time $t = 0$. Consequently, the country runs a surplus on its trade balance in periods $t \in (0, T)$ while it runs a deficit on the trade balance in periods $t \in (T, \infty)$.

Turning to the role of asset holdings, remember that the path of private sector holdings of foreign bonds is given by (7). Also remember that when evaluating (7) over the life-horizon, the difference between discounted income and discounted full consumption must equal the given level of initial wealth a_0 as in (8). Therefore, in order to study the development of a_t , consider the change in capital at two points in time: a point in time before T and a point in time after T . In appendix A, it is demonstrated that at any time point s , $0 < s < T < \infty$, where the stabilization plan is effective asset holdings are increasing, $\frac{\partial a_s}{\partial s} > 0$, and that at any time point

l , $0 < T < l < \infty$, after the breakdown of the stabilization plan asset holdings are decreasing, $\frac{\partial a_t}{\partial t} < 0$, i.e. the domestic agents save in periods between $t = 0$ and $t = T$ and unload savings in periods after time $t = T$. This works in the following way: Whether or not the change in consumption at time $t = 0$ is positive or negative, the change in output is always larger than the change in consumption implying that some of the initial change in output is saved, and saved abroad. This causes asset holdings to increase during the stabilization plan, and the agents can thus perfectly smooth out consumption.

The above results are summarized below and illustrated in Figure 2 for a stabilization program that yields a positive effect on consumption.

Summary 1. Real effects of a temporary exchange-rate-based stabilization plan when money is a productive factor:

1. *Consumption is changed from c_0 to \hat{c} in period $t = 0$, i.e. consumption (and output) are not superneutral with respect to changes in the rate of devaluation. In period $t = T$, no change in consumption is realized. Money holdings increase at time $t = 0$ and decrease at time $t = T$.*
2. *The longer is the interim period with the lower rate of inflation, the higher is the likelihood that the change in consumption is positive. For $T \rightarrow \infty$, consumption is increased when the plan is implemented whereas for $T = 0$, consumption falls when the plan is implemented.*
3. *One way, in this model, to secure utility-enhancing ERB stabilization plans is to increase taxes when the plan is implemented; taxes have to be set such that part of the initial boom in output is saved to replace interest earnings lost in the defense of the policy of the low rate of exchange rate devaluation.*
4. *If consumption increases, utility increases. Utility is permanently influenced by the temporary reduction in inflation, and the longer the period with the low rate of inflation, the more utility is increased.*
5. *The private agents perfectly smooth out consumption by piling up international assets when production is high and unload international assets when production is low.*

[INSERT FIGURE 2 ABOUT HERE]

5.5 Discussing the results in light of the existing literature

How do the results summarized above differ from the existing one? First, compare with models of exchange-rate-based stabilization plans that include money in the utility function of the consumer and assume that there are no supply-side effects associated with the stabilization plan, such as the models in Obstfeld (1985, 1986), Claessens (1988), Bacchetta (1990), and Daniel (2000). In these models, as mentioned earlier, a temporary stabilization plan has no effect on production, and effects on real consumption arise only if the cross-derivative of the utility function is different from zero. For instance, Claessens (1988) reports that when the coefficient of intertemporal substitution in consumption is less than one, the drops in consumption and money holdings at time $t = T$ are larger than the positive jumps in consumption and money holdings at time $t = 0$, i.e. utility is seemingly negatively influenced. For a coefficient of intertemporal substitution in consumption larger than one, consumption declines at time $t = 0$, but increases after time $t = T$ to a level higher than it was before the implementation of the stabilization plan. Money holdings, on the other hand, fall both at $t = 0$ and $t = T$, and the total effects on utility are ambiguous. As the third situation, consider the case where the parameter measuring the intertemporal substitution in consumption equals exactly one. In this case, the utility function is separable in money and consumption and consumption will not be affected by the stabilization plan whereas money holdings are obviously higher. Therefore, when $u_{cm}c = 0$, utility is temporarily increased during the stabilization plan due to the higher money holdings and zero effect on consumption, but falls back to the initial level when the stabilization plan breaks down. Furthermore, notice that none of the above-mentioned models generate effects on output, i.e. the models cannot capture the boom-bust cycles in output often experienced after implementations of ERB plans. To summarize: in models that include money in the utility function and leave no room for supply-side effects, the final effects on utility are in some situations negative, at best unambiguous, and in all cases depend crucially on the size of the coefficient of intertemporal substitution in consumption – a result that has been characterized as somewhat disturbing.²⁰ Moreover, the models cannot capture boom-bust cycles in output.

Second, compare with models of temporary exchange-rate-based stabilization plans that

²⁰Obviously, the results in this paper are based on a utility function with a coefficient of intertemporal substitution in consumption that equals one. But, as mentioned in footnote 9, this restriction can be removed without any qualitative effects on the results; the results will just look more “complicated”.

obtain a role for money by assuming that money is the only available medium of exchange such that money is needed when the consumer purchases and sells goods, i.e. models using Cash-in-Advance constraints, as for instance Calvo (1986) and Calvo & Végh (1993). With a Cash-in-Advance constraint, money is closely tied to consumption implying that the effective price of consumption is reduced in periods where the rate of inflation is low and money holdings high, relative to the effective price of consumption in the future periods where inflation is high again and money holdings low, i.e. an initial boom and a later reduction in consumption will be realized.²¹ Due to the fact that there are no supply-side effects in these models, though, the higher consumption during the stabilization program implies that the country runs a current-account deficit in this interim period so that the net foreign assets of the country are lower after the breakdown of the plan. The lower holdings of net foreign assets and thus lower national wealth influence the intertemporal budget constraint of the country, and discounted life-time consumption will be reduced. This implies that utility is reduced or, to quote Reinhart & Végh (1995), pp. 375: “temporary stabilization is always welfare decreasing in cash-in-advance models”, because there are no wealth effects which may offset the intertemporal distortions.

Finally, Calvo & Végh (1999) mention that “a temporary stabilization may be welfare improving if the benefits (in terms of freed resources) of temporarily-lower inflation more than offset the intertemporal distortion caused by a non-constant path of the nominal interest rate (see Reinhart & Végh (1995)). Hence, policymakers may still find it optimal to implement stabilization plans that may not be fully credible, provided they commend a “reasonable” level of credibility”. This finding is in accordance with the results of the present paper.

The upshot of this small comparison with other models on temporary exchange-rate-based stabilization plans is that if money is introduced through Cash-in-Advance constraints, utility is normally reduced as a result of the stabilization plan, whereas if money is introduced through a non-separable utility function, the effects on utility are, to a somewhat disturbing extent, dependent on the size of the parameter measuring the intertemporal substitution in consumption and there are no effects on output. In the simple model of this paper where utility is separable in money and consumption and money plays a productive role, a boom-bust cycle in output

²¹Actually, on this issue, Calvo & Végh (1999) report that the models have some difficulties in explaining the empirical evidence, as the empirical estimates of the parameter measuring the degree of intertemporal substitution in consumption are generally found to be quite low - and a low estimate of this parameter makes it difficult to explain a significant initial increase and later reduction in consumption by referring to an intertemporal substitution in consumption.

occurs and utility is always increased if one of the following two conditions is fulfilled: the ERB stabilization plan is believed to last sufficiently long and/or part of the initial boom in output is saved to replace interest earnings from the foreign exchange reserves lost in a future defense of the plan.

6 The speculative attack

Assume now that until period $t = 0$ inflation is at a level consistent with the fiscal requirements of the government, i.e. assume that until the implementation of the stabilization program $\pi_0 = \tilde{\pi}$ and foreign exchange reserves are constant. In period $t = 0$, the unanticipated change in the exchange rate policy takes place, and the rate of devaluation is reduced to zero whereas the growth rate of nominal domestic credit remains unchanged at σ . From period $t = 0$, therefore, $\pi_1 < \tilde{\pi} = \pi_0$ and foreign exchange reserves are being depleted because of the assumption that the total proceeds from the inflation tax are reduced as a consequence of the implementation of the plan, as discussed thoroughly in section 3.1.2.²² In this model it is thus known that at some future point in time foreign exchange reserves will reach the critical point $R = 0$; furthermore, the private agents can calculate when foreign exchange reserves are at their minimum because of the perfect foresight assumption coupled with the deterministic environment.²³

A crucial point in the currency crisis literature is that the agents launch the speculative attack *before* the foreign exchange reserves have been depleted. Why is this so? Consider the case where the agents do not launch the attack before reserves are at their minimum. In this

²²To recapitulate: In section 3.1.2, it was argued that this is a quiet reasonable assumption given that the model predicts that the revenues from both the firms' holdings of money and the revenues from the consumers' current holdings of money are reduced. Furthermore, there is ample empirical evidence that temporary ERB stabilization plans are associated with falling foreign exchange reserves.

²³Notice that the speculative attack in this model, as in the original Krugman (1979) model and the subsequent first-generation models, occurs at time $t = T > t = 0$. In a recent paper, Daniel (2000) shows how the assumption of a speculative attack occurring later than the date at which the stabilization plan is implemented implies that it is implicitly assumed that the government uses the excess seigniorage (excess in the sense that the revenues from seigniorage are higher than they would have been with a policy that is consistent with the maintenance of the fixed exchange rate) to finance the loss of exchange reserves. In particular, Daniel (2000) shows that if the government instead used the excess revenues to increase lump-sum transfers to the consumers, the speculative attack would occur exactly at the date in time where the stabilization plan is implemented. To keep reference to the Krugman (1979) based literature, this paper assumes that government transfers g are constant during the stabilization plan – but of course reduced to g^* after time $t = T$.

case, the private agents will experience a relative capital loss on the part of their asset holdings which is denominated in domestic currency, because the nominal exchange rate jumps when the devaluation takes place. In order to avoid this capital loss, the private agents will try to control the date in time when the government changes the nominal exchange rate.

After the speculative attack, the exchange rate will be determined by traditional economic factors, i.e. it will not be managed in any way. When the private agents know the value of the nominal exchange rate after the managed exchange rate policy has been abandoned, they can launch a speculative attack at the moment in time when the exchange rate policy change implies that *no* discrete jump in the nominal exchange rate occurs. Utilizing this knowledge, the exact period in time where the speculative attack takes place, as well as the size of the speculative attack, can be calculated.²⁴

6.1 Determination of the speculative attack

Just after the flotation of the exchange rate at time $t = T$, foreign exchange reserves are zero, i.e. $R_{T+} = 0$. What remains to be determined is the size of the foreign exchange reserves just before the speculative attack. As $\dot{R} = \pi m - [g + r^f(F - R)]$, the size of reserves preceding the attack is:

$$\begin{aligned} R_{T-} &= \int_0^T \left[\pi_1 (m_1^C + m_1^F) - g - r^f F \right] e^{r^f t} F + R_0 e^{r^f T} \\ &= \frac{[\pi_1 (m_1^C + m_1^F) - g - r^f F] (e^{r^f T} - 1)}{r^f} + R_0 e^{r^f T}. \end{aligned} \quad (61)$$

At the point of transition, a jump in real money balances is realized due to the change in the consumer's and the firm's demand for money. This jump will equal:

$$\Delta m = (m_T^C - m_1^C) + (m_T^F - m_1^F) = \left(\gamma + \frac{1 - \alpha}{\alpha} \hat{c} \right) \left(\frac{1}{r^f + \pi_0} - \frac{1}{r^f + \pi_1} \right) < 0. \quad (62)$$

²⁴In the speculative attack literature the value of the exchange rate when reserves are at their minimum is often called “the shadow exchange rate”, i.e. this is the exchange rate that would prevail if the exchange rate was floating. The intuition of the above reasoning is that if the shadow exchange rate is above the value of the managed exchange rate, the private agents can sell all their domestic currency for foreign currency, forcing the abandonment of the managed exchange rate policy and make an instantaneous gain as they can thereafter sell their foreign currency at the higher domestic price. If the shadow rate is lower they would experience a capital loss. When perfect foresight prevails, the agents will not expect a jump in the exchange rate as such jumps will immediately be eliminated by arbitrage. This implies that the collapse will appear when the “shadow exchange rate” equals the prevailing fixed exchange rate.

Turning to the speculative attack, this “attack” will occur exactly when the change in the demand for real money balances equals the size of the foreign exchange reserves as it is only in this situation that the private agents can control the timing of the collapse of the exchange rate policy. The negative change in the demand for money implies that the private agents will sell domestic currency for foreign currency leading to a decrease in the foreign exchange reserves. The speculative attack will therefore occur when:

$$\Delta m = (m_T^C - m_1^C) + (m_T^F - m_1^F) = R_{T+} - R_{T-} = -R_{T-}. \quad (63)$$

Equation (61) together with (63), gives the size of the speculative attack. From (63) the time at which the speculative attack will be launched can implicitly be written as

$$\begin{aligned} & - \frac{[\pi_1 (m_1^C + m_1^F) - g - r^f F] (e^{r^f T} - 1)}{r} - R_0 e^{r^f T} \\ & = \left(\gamma + \frac{1 - \alpha}{\alpha} \hat{c} \right) \left(\frac{1}{r^f + \pi_0} - \frac{1}{r^f + \pi_1} \right), \end{aligned} \quad (64)$$

where \hat{c} is given in (51) and depends on T .

It is noteworthy that if the nominal interest rate elasticity of the consumer’s money demand function equalled zero, i.e. if $(m_T^C - m_1^C) = 0$, a speculative attack will in this model occur nevertheless, as a change in the exchange rate changes firms’ demand for money. This contrasts to the findings in Grilli (1986), who finds that if the interest rate elasticity of the demand for money equals zero, no speculative attack will occur, and the transition from a pegged to a floating exchange rate regime will occur only when foreign exchange reserves have reached their critical level. The obvious reason for the speculative attack in the present model, even if the consumers’ demand for money does not depend on the nominal interest rate, is that the jump in the demand for money comes from two sources: the consumers and the firms. The point here is that both the firms and the consumers would launch a speculative attack if they would otherwise realize a relative capital loss.

These results of this section are summarized below.

Summary 2. The speculative attack when money is a productive factor:

1. *The timing of the speculative attack is determined by the interest rate elasticity of the consumer’s demand for money as well as by the firm’s demand for money.*
2. *There is a speculative attack even if the interest rate elasticity of the consumer’s demand for money equals zero. Only when both (i) the consumer’s demand for money is interest*

rate inelastic and (ii) the firm's demand for money is interest rate inelastic will the stabilization plan collapse in a "natural" way, and there will be no speculative attack.

A note on the current account. Before closing the analysis of the effects of the ERB stabilization plan, it is useful to consider the consequences for the current account. One effective way to determine whether there is a surplus on the current account or not is to study the path of total net foreign assets in the economy.

The path of net foreign assets was found to equal $\dot{Z} = r^f Z + y - c$ with $\dot{Z} = \dot{a} - \dot{m} + \dot{R}$. In section 5.3, it was shown that in periods $t \in (0, T)$, $\dot{a} > 0$ and, from (37), $\dot{m} = 0$ whereas in periods $t \in (T, \infty)$, $\dot{a} < 0$ and, from (37), still $\dot{m} = 0$. Furthermore, as shown in the previous section, when $\pi_1 = \bar{\pi} < \tilde{\pi} = \pi_0$, $\dot{R} < 0$, whereas $\dot{R} = 0$ after the breakdown of the stabilization plan, i.e. in periods $t \in (T, \infty)$, $\dot{Z} = \dot{a} < 0$ and the country runs a deficit on its current account.

The intertemporal resource constraint of the country reads:

$$Z_0 = \int_0^{\infty} (y - c) e^{-r^f t} dt + \lim_{t \rightarrow \infty} Z_t e^{-r^f t}$$

Imposing the transversality condition $\lim_{t \rightarrow \infty} Z_t e^{-r^f t} = 0$, it follows that $\dot{Z} > 0$ in periods $t \in (0, T)$, when knowing that in periods $t \in (T, \infty)$, $\dot{Z} = \dot{a} < 0$, i.e. the country runs a surplus on its current account during the stabilization plan and a deficit after the breakdown of the plan.

7 Concluding remarks

It is probably fair to argue that many observers during the late 1990s held the view that exchange-rate pegs of the so-called "soft type" were appropriate only in the initial phases of inflation stabilizations and that hard pegs "may be the only sustainable monetary strategy for those Latin American countries whose political and economic institutions cannot support an independent central bank focused on preserving price stability" (Mishkin & Savastano, 2001, pp. 423 for the medium term.²⁵ Unfortunately, Argentina's recent experiences reveal how hard pegs can as well be plagued by severe shortcomings. Is the only *truly* available exchange rate strategy that remains then is a floating exchange rate? Most likely, the answer to this question is no. First, countries plagued by histories of high rates of inflation can probably only gain a high enough level of credibility for their newly implemented low-inflation policies by importing

²⁵Also see: Obstfeld & Rogoff (1995b), Mishkin (1999), and Larrain & Velasco (2001).

credibility from abroad, and one way to do this is to link the movements of domestic price to those of foreign prices by means of some version of a pegged exchange rate mechanism. Second, it is at present not clear whether systems of pegs can be redesigned so as to provide a better shelter against some of the problems associated with the use of exchange rate pegs.²⁶ Third, exchange rate pegs are simply what are used in many countries. According to the International Financial Statistics of the IMF, in June 2002, 63 countries pegged their currency to that of another country in some way or another.²⁷ In addition to this number, 40 countries had no separate legal tender and 43 countries had a managed floating exchange rate, leaving only 40 IMF member countries with a strategy of having their exchange rate independently floating. The bottom line is that exchange rate pegs are probably here to stay and, particularly relevantly for this paper, pegs will probably remain the “best” strategy to pursue in the initial phases of stabilization programs for countries plagued by histories of very high rates of inflation (see for instance the quotation from Fisher *et al.*, 2002 given in the introduction to this paper).

With this in mind, the present paper studied how and if exchange-rate based stabilization plans could be made beneficial to the economy, especially in terms of ERB plans that remain temporary only. The most important results were the following. Under the restrictive assumption that the coefficient of relative risk aversion is exactly equal to one, a Sidrausky-like model can generate a temporary positive effect on utility from a temporary exchange-rate-based stabilization because money holdings are higher during the ERB stabilization plan, and there are no effects on consumption. Unfortunately, such a model is embarrassingly silent, though, with respect to issues such as why there is often a boom-bust cycle in output associated with an ERB stabilization plan. The predictions of such a model, too, are dependent upon the precise sizes of parameters about which it is difficult to have a clear a priori opinion.²⁸ As an alternative, this paper illustrated that a reduction in the rate of devaluation increases the utility of the representative consumer, despite the fact that the reduction is known to be temporary only, if the ERB plan has a positive effect on output, lasts sufficiently long, and/or some of

²⁶Some authors, for instance Eichengreen *et al.* (1995), have argued that there should be thrown “sand in the wheels of international finance”.

²⁷8 countries had currency boards, 40 countries had “other conventional” fixed peg arrangements, 5 countries had their exchange rate pegged within horizontal bands, 4 countries had crawling pegs, and 6 countries had their exchange rates pegged within crawling horizontal bands.

²⁸To repeat from footnote 7, Obstfeld (1985) writes: “It is somewhat disturbing that the model’s predictions depend so strongly on this sign”, i.e. depend so strongly upon the coefficient of intertemporal substitution in consumption and especially whether this coefficient is higher than, less than, or equal to one.

the high output during the stabilization plan is saved to bad times after the breakdown of the plan. Finally, the paper also made clear that only when both consumers' and firms' demand for money do not depend on the nominal interest rate, will the collapse of the exchange-rate-based stabilization plan occur in a "natural manner", i.e. without a speculative attack on the exchange rate.

A central feature of the model was that money was allowed to play a productive role. Including money in the production function is the most simple way of capturing the effect that production does react to changes in the rate of inflation. The assumption enables one to obtain effects on real output and consumption from a change in the monetary regime even when the economy is as "perfect" as possible, i.e. when all prices are fully flexible, perfect competition and perfect information prevails, no externalities or rigidities are present, and so forth. The idea of the paper is that the assumption of a productive role for money seems reasonable if firms' production is relatively low in times when the inflation rate is high, due to inflation's disruptive effect on normal payment practices and trading patterns.²⁹

It should be noted, however, that the short-cut of including money in the production function of firms also suggests one way the model of this paper could be extended. Instead of assuming that money influences production, it could be modelled why money influences production. Alternative ways of obtaining real effects from changes in money could be rationalized by leaving the "perfect competition/no rigidity economy" and study situations with monopolistic competition on the goods market coupled with non-continuous price and wage adjustments.³⁰ Incorporating such features would give rise to gradual changes in production due to gradual changes in wages and prices as opposed to the one-time changes at $t = 0$ and $t = T$ studied in this paper. As an alternative to a New Keynesian inspired set-up, one could relax the assumption of perfect information along the lines of the literature on credit-market imperfections

²⁹As the New Palgrave Dictionary of Money and Finance (1992), pp. 327, writes on hyperinflation: "In several countries output rose in the early stage of hyperinflation but ultimately declined when the disrupting effects of inflation on payment practices and normal trading patterns became too severe. In other episodes, real output declined throughout the progressive flight from money".

³⁰Mankiw & Romer (1992) for instance, survey the New Keynesian closed-economy literature that *inter alia* describes these ways of obtaining real effects of money and Obstfeld & Rogoff (1995a) incorporated such features into models of open economies thereby starting what is now known as the "New open-economy macroeconomics", see Lane (2001). Notice however that Benhabib & Farmer (2000) include money in the production function of firms exactly because they are interested in finding room for real effects of money *without* imposing an assumption of rigid wages or prices.

as for instance in Stiglitz & Weiss (1992). In such a setting, it is the factors that determine the amount of credit to which firms have access that influence production, as opposed to the present paper where the positive relation between money holdings and production arises due to a reduced *demand* for money when inflation is high. Without explicit reference to and modelling of what causes the credit-market imperfections, van Wijnbergen (1983) is an early example of a model where bank credit is used to finance working and fixed capital so that credit influences investments and production, i.e. a situation with a positive relation between credit and production, as in this paper, but where this positive relation arises due to factors influencing the supply of credit. In the same vein, Edwards & Végh (1997) is a more recent example of a model where credit determines the level of output as it is assumed that bank credit must be used to pay wages and thereby influences the level of employment and thus output. Assuming that prices are rigid or information is imperfect, though, would give rise to a very different paper, and therefore also redirect focus towards issues that are explicitly not dealt with in this paper.

Inspired by Benhabib *et al.* (2001), this paper included money in both the consumer's utility function and the firm's production function. It is actually not necessary to include money in the utility function in order to generate a positive effect on welfare from temporary exchange-rate stabilization. What is needed is that money influences the consumer's budget constraint, and thereby his permanent income, so that the larger money holdings during the stabilization plan enable the consumer to increase consumption. The reason for including money in the utility function is that it permits a comparison with the rest of the literature on speculative attacks. The assumption makes it possible to derive the conditions under which no speculative attack occurs, and thus gives rise to the result that both consumers' and firms' demand for money should be independent of the interest rate if there should be a "natural collapse".

Finally, with respect to the empirical effects actually observed in exchange-rate-based stabilization programs, this model captures the initial booms in output and consumption, the later contractions in output, the speculative attacks on the exchange rate, the reductions and later increases in the rate of inflation, and the later current account deficits. What the paper does not capture, however, is the initial real exchange rate appreciation experienced in some exchange-rate-based stabilization programs.³¹ The reason for this is, of course, that it is as-

³¹An interesting recent paper dealing with the movements of both consumption and the real exchange rate throughout ERB stabilization plans is Uribe (2002). In addition to explaining the "price-consumption puzzle of currency pegs" by allowing preferences to be non-separable over time through habit formation, Uribe (2002)

sumed that there is only one good in the economy and thus only one price. The one-good model is used for two reasons: (i) to keep the model simple but still detailed enough to allow for a dynamic optimizing framework such that the effects on utility can be analyzed and (ii) to make straightforward a comparison with the existing literature that uses one-good models, such as Obstfeld (1986), Claessens (1988), Bacchetta (1990), Edwards & Végh (1997), Daniel (2000), and Agénor & Piazzati (2000).

In summary: the intention with this paper was to make clear that if money influences permanent income of the consumer, an exchange-rate-based stabilization plan will have consequences on welfare in an optimizing model. It is left for future research to develop models that incorporate in greater detail the reasons why money changes permanent income and models that describe what happens to the prices of respectively traded and non-traded goods during the stabilization plan.

also gives a brief review of the more traditional models proposed to explain ERB stabilization plans.

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Appendix A

In this appendix, the dynamics of capital at a time point s , $0 < s < T < \infty$ and a time point l , $0 < T < l < \infty$ will be calculated.

The level and dynamics of capital at time s , $0 < s < T < \infty$

The level of capital at a time point s for $0 < s < T < \infty$ is from (8) given by,

$$\begin{aligned} a_s = & \int_0^s y_1 e^{r^f t} dt + \int_s^T y_1 e^{-r^f t} dt + \int_T^\infty y_T e^{-r^f t} dt + \int_0^s g e^{r^f t} dt + \int_s^T g e^{-r^f t} dt \\ & + \int_T^\infty g^* e^{-r^f t} dt - (r^f + \pi_1) \left[\int_0^s (m_1^C + m_1^F) e^{r^f t} dt + \int_s^T (m_1^C + m_1^F) e^{-r^f t} dt \right] \\ & - (r^f + \pi_0) \int_T^\infty (m_T^C + m_T^F) e^{-r^f t} dt - \int_0^s \widehat{c} e^{r^f t} dt - \int_s^\infty \widehat{c} e^{-r^f t} dt \end{aligned}$$

for $a_0 = 0$. Calculating the different terms, the level of capital in any time period before $t = T$ is:

$$\begin{aligned} a_s r^f = & \left[y_1 + g - m (m_1^C + m_1^F) (r^f + \pi_1) - \widehat{c} \right] (e^{r^f s} + e^{-r^f s} - 1) + (y_T - y_1) e^{-r^f T} \\ & + (g^* - g) e^{-r^f T} - \left\{ (m_T^C + m_T^F) (r^f + \pi_0) - (m_1^C + m_1^F) (r^f + \pi_1) \right\} e^{-r^f T} \end{aligned}$$

Differentiation of a_s with respect to s , shows how the consumer's holdings of capital develops over time in periods before $t = T$:

$$\frac{\partial a_s}{\partial s} = \left[y_1 + g - \widehat{c} - (m_1^C + m_1^F) (r^f + \pi_1) \right] (e^{r^f s} - e^{-r^f s})$$

In section 2, it was shown that $c + m^C (r^f + \pi) = \frac{c}{\alpha}$. Furthermore, (51) revealed how the level of consumption was determined after the implementation of the stabilization program. Finally remembering that the firm's demand for money is given by $m = \frac{\gamma}{r^f + \pi}$, $\frac{\partial a_s}{\partial s}$ can be written as

$$\frac{\partial a_s}{\partial s} = [(y_1 - y_T) + (g - g^*)] e^{-r^f T} (e^{r^f s} - e^{-r^f s}) \quad (A1)$$

$$= \left[\ln \left(\frac{r^f + \pi_0}{r^f + \pi_1} \right) + (g - g^*) \right] e^{-r^f T} (e^{r^f s} - e^{-r^f s}) \quad (A2)$$

which is strictly positive for positive interest rates (so that $0 < e^{-r^f T} < 1$), because $y_1 > y_T$ due to the lower rate of devaluation and because $g > g^*$ due to the loss of the exchange reserves after the defense of the fixed exchange rate regime.

The level of capital at time l , $0 < T < l < \infty$

The level of capital at a time point l for $0 < T < l < \infty$ is given by,

$$\begin{aligned}
a_l = & \int_0^T y_1 e^{r^f t} dt + \int_T^l y_T e^{r^f t} dt + \int_l^\infty y_T e^{-r^f t} dt + \int_0^T g e^{r^f t} dt + \int_T^l g^* e^{-r^f t} dt \\
& + \int_l^\infty g^* e^{-r^f t} dt - (r^f + \pi_1) \int_0^T (m_1^C + m_1^F) e^{r^f t} dt - (r^f + \pi_0) \left[\int_T^l (m_T^C + m_T^F) e^{r^f t} dt \right. \\
& \left. + \int_l^\infty (m_T^C + m_T^F) e^{-r^f t} dt \right] - \int_0^l \widehat{c} e^{r^f t} dt - \int_l^\infty \widehat{c} e^{-r^f t} dt.
\end{aligned}$$

for $a_0 = 0$. Calculating the different terms, the level of capital in any time period after $t = T$ is:

$$\begin{aligned}
a_l r^f = & \left[y_T + g^* - (m_T^C + m_T^F) (r^f + \pi_0) - \widehat{c} \right] (e^{r^f l} + e^{-r^f l}) + (y_T - y_1) e^{r^f T} \\
& + (g^* - g) e^{r^f T} - \left(y_1 + g - (m_1^C + m_1^F) (r^f + \pi_1) - \widehat{c} \right) \\
& - \left\{ (m_T^C + m_T^F) (r^f + \pi_0) - (m_1^C + m_1^F) (r^f + \pi_1) \right\} e^{r^f T}
\end{aligned}$$

Differentiation of a_l with respect to l , shows how the consumer's holdings of capital develops over time in periods after $t = T$,

$$\frac{\partial a_l}{\partial l} = \left[y_T + g^* - (m_T^C + m_T^F) (r^f + \pi_0) - \widehat{c} \right] (e^{r^f l} - e^{-r^f l})$$

which can be written as,

$$\frac{\partial a_l}{\partial l} = [(y_T - y_1) + (g^* - g)] (1 - e^{-r^f T}) (e^{r^f l} - e^{-r^f l}) \quad (A3)$$

$$= \left[\ln \left(\frac{r^f + \pi_1}{r^f + \pi_0} \right) + (g^* - g) \right] e^{-r^f T} (e^{r^f s} - e^{-r^f s}) \quad (A4)$$

and is strictly negative for positive interest rates.

Figures

Figure 1: The path of inflation

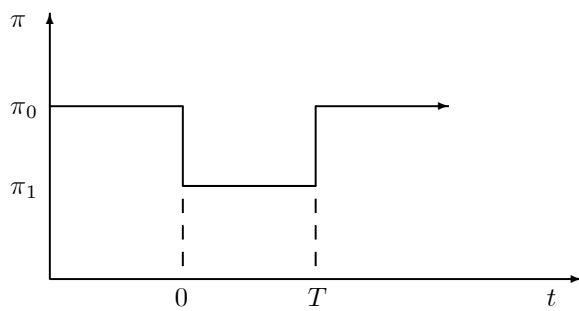


Figure 2: The paths of utility, production, consumption, and m^c when the ERB stabilization plan has a positive effect on consumption

